EXHIBIT D

February 13, 2024

United States District Court for the District of New Jersey

Expert Report of Dr. Samuel S.-H. Wang

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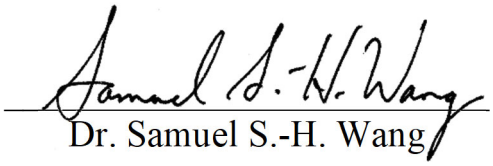

Dr. Samuel S.-H. Wang

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1. SUMMARY OF FINDINGS

1) New Jersey primary ballots display candidates for different offices on a single column or row (the "county line"). The county line is a nonstandard design feature that does not appear on conventional ballots, which present each office with its own separate list of candidates. Often each set of candidates on the line is identified by its own distinctive slogan. The neuroscience of how brains process visual information suggests that this party column ballot design would tend to unduly favor the candidates on the line.

2) The party column ballot design leads to a pattern of outcomes that deviates from expectations based on other designs with high statistical significance. The New Jersey ballot's county line is associated with an advantage that accrues to both new candidates and incumbents, and to candidates for legislature, governor, U.S. House, and U.S. Senate.

3) State legislative candidates gain a highly statistically significant advantage from being on the county line. From 2009-2022, incumbent legislators nationwide lose their primaries at a rate of 3.4%, whereas New Jersey incumbents running on the county line were 11 times less likely to lose their primaries, a rate of 0.3%.

4) Candidates for U.S. Senate and House who were on the county line had a vote share that was 38 points larger on average than if their opponents had the county line, a highly statistically significant difference. In situations where a nonincumbent candidate had the party endorsement, nonincumbent candidates for governor, U.S. Senate, and U.S. House had a vote share that was 17 points larger in situations where they were on the county line than situations where they were not.

5) The size of the bias arising from the party column ballot design is larger than that which typically occurs in other features of ballot design. Specifically, the effect is larger than that found in previous studies of the primacy effect, an effect which arises from the order in which candidates are listed on a conventional office block-design ballot and which has often been found to be unconstitutional.

6) A parsimonious explanation of these findings is that the physical and geometric arrangement of candidate names on the county line acts as a powerful force to steer voter behavior towards specific choices. I find that the New Jersey party column ballot design guides the brain's decision-making mechanisms to provide persistent advantages to candidates who are on the county line, and these advantages go beyond those of party endorsement or incumbency status.

2. INTRODUCTION

2.1 STATEMENT OF PURPOSE

This report evaluates the size and statistical significance of effects associated with New Jersey's party column primary ballot system (notably the "county line"), as well as the brain mechanisms that give rise to such effects. The report consists of three parts: (1) an examination of the design of the ballot and possible consequences based on neuroscience; (2) quantification of effects; and (3) comparison with other effects that have been previously found to be a violation of voting rights.

2.2 QUALIFICATIONS

I am a professor of neuroscience at Princeton University, whose faculty I joined in 2000. I hold a bachelor of science degree with honor in physics from the California Institute of Technology and a Ph.D. in neuroscience from Stanford University. I am also Director of the Electoral Innovation Lab, an independent organization dedicated to nonpartisan research on the mechanisms of U.S. democracy. In my academic career I have published over 100 peer-reviewed articles in neuroscience, election science, statistics, and the law of democracy. Nearly all of these articles use statistical testing, including the development of new statistical methods to address specific data problems in the natural sciences and in the study of elections. My neuroscience research addresses how brains learn from sensory experience, and has been published in leading scientific journals including *Nature*, *Neuron*, and the *Journal of Neuroscience*. At Princeton University I have taught extensively in all areas of neuroscience at the undergraduate and graduate level, as well as classes in molecular biology, psychology, and the School of Policy and International Affairs.

My research on election science and the law of democracy has been published in leading law and scientific journals including *Proceedings of the National Academy of Sciences*, *Stanford Law Review*, *Election Law Journal*, *Harvard Law and Policy Review*, and the *University of Pennsylvania Journal of Constitutional Law*. I am familiar with electoral statistics in the state of New Jersey: in 2021 and 2022, I served as the technical advisor to the chair of the New Jersey Redistricting Commission, and to the tiebreaking 11th member of the New Jersey Apportionment Commission.

In federal court I served the Attorney General of Maine in *Lew Hagopian et al v. Dunlap et al.* regarding ranked-choice voting elections. In the Supreme Court of North Carolina, I served as an assistant to the Special Masters in the redistricting cases of *Harper v. Hall* and *North Carolina League of Conservation Voters v. Hall.* In all of these cases I was deemed qualified as an expert. My CV is attached to this report.

For services provided in connection with this matter I am being compensated at the rate of $400 per hour. This compensation does not depend in any way on the results of my analysis or the conclusions that I draw.

2.3 EVIDENCE AND METHODOLOGY

This report evaluates the party column ballot design using principles of decision-making and visual processing that are well-known in neuroscience, cognitive science, and psychology. This report also uses basic statistical tests to compare groups of election results that differ in a feature of specific interest (for example, whether a candidate is on the county line or not) but share features that are not the topic of investigation (for example a party endorsement). I performed statistical analysis of a type reported in my own recent scholarly publication on New Jersey ballots and elections, using data found in publicly available factual research[1]. These data were used to make comparisons between closely matched conditions, a method that is standard in the natural and social sciences and which is often referred to as a natural experiment. Conditions were evaluated using standard statistical tests, including tests to compare whether one group of numerical observations is larger than another or differs from zero (the t-test), as well as tests to determine whether two ratios of win/lose observations differ from one another (the Fisher exact test and the chi-square test). I have made frequent use of these tests in the sciences and in election law[2].

3. BACKGROUND: THE COUNTY LINE

Most primary ballots in New Jersey follow an unusual design in which candidates for a particular office do not appear in simple list form (sometimes called a "bubble ballot" or an office block ballot), as other states do. Instead, New Jersey's party column ballot is laid out with many blank spaces, overall forming a pattern that arranges candidates favored by party committees[3] in a concentrated column or row. The party county committee supplies candidate names and affiliations and county clerks are responsible for determining the pattern. Often each list is identified by its own distinctive slogan. Such an approach to ballot design creates what is called the "county line."

For a major political party's primary election in New Jersey, all candidates, including for President, governor, and U.S. Senate, and U.S. House, can align with candidates for other

[1] S.S.-H. Wang, H. Goldberg, and J.S. Rubin, *Three Tests for Bias Arising From the Design of Primary Election Ballots in New Jersey*, 48 SETON HALL J. LEGIS. & PUB. POL'Y, 24-47 (2023); J.S. Rubin, *Does the County Line Matter? An Analysis of New Jersey's 2020 Primary Election Results*, N.J. POL'Y PERSP.; J.S. Rubin, *The Impact of New Jersey's County Line Primary Ballots on Election Outcomes, Politics, and Policy*, 48 SETON HALL J. LEGIS. & PUB. POL'Y, 48-69 (2023). For a detailed accounting of data see expert report in the current case by Prof. Rubin.

[2] For example, see S.S.-H. Wang, *Three Tests for Practical Evaluation of Partisan Gerrymandering*. 68 STANFORD LAW REVIEW, 1263-1321 (2016). For further examples see Wang CV.

[3] For the sake of brevity, in this report I will refer to the "county committee" or "party committee" as the entity whose decision, in practice, ultimately leads to communication to the county clerk who will receive the status of county line candidates. In some counties, the endorsement of a slate of candidates is conferred by the county party committee: generally, a group of party leaders who each represent a voting precinct in the county, or the party committee's members from a particular municipality for races in that municipality. In other counties endorsements are conferred by mayors, by a much smaller group of party leadership, or by the county chair alone. Technically, such endorsements are not binding on who is awarded the county line on the ballot, as the final decision is ultimately vested in the campaign manager for county commissioner candidates pursuant to N.J.S.A. 19:49-2.

offices on the ballot. This process is known as bracketing. Subject to laws governing which candidates are eligible to be listed first, county clerks determine the placement of candidates on the ballot, and they exercise discretion under New Jersey law to select the office to draw for ballot position. The selected office then becomes the pivotal office around which other races' candidates are arranged. Co-bracketed candidates for other offices are then added to the resulting columns, as appropriate. Co-bracketed candidates may also share a slogan which further identifies their connection to one another. Next, unbracketed candidates are drawn for placement in other columns further to the right. Using their discretion, county clerks can put unbracketed candidates in separate columns, pushing them further to the right or bottom of the ballot.

The physical consequence of the county line mechanism is a thick, visually distinctive "line" of candidates bracketed together, usually in the form of a column near the left edge of the ballot. Figure 1, which shows the ballot for the 2020 Cumberland County Democratic Primary in New Jersey's Second Congressional District, is such an example. Unbracketed candidates appear in disorganized-looking patterns, often interspersed with significant whitespace or in hard-to-find locations.

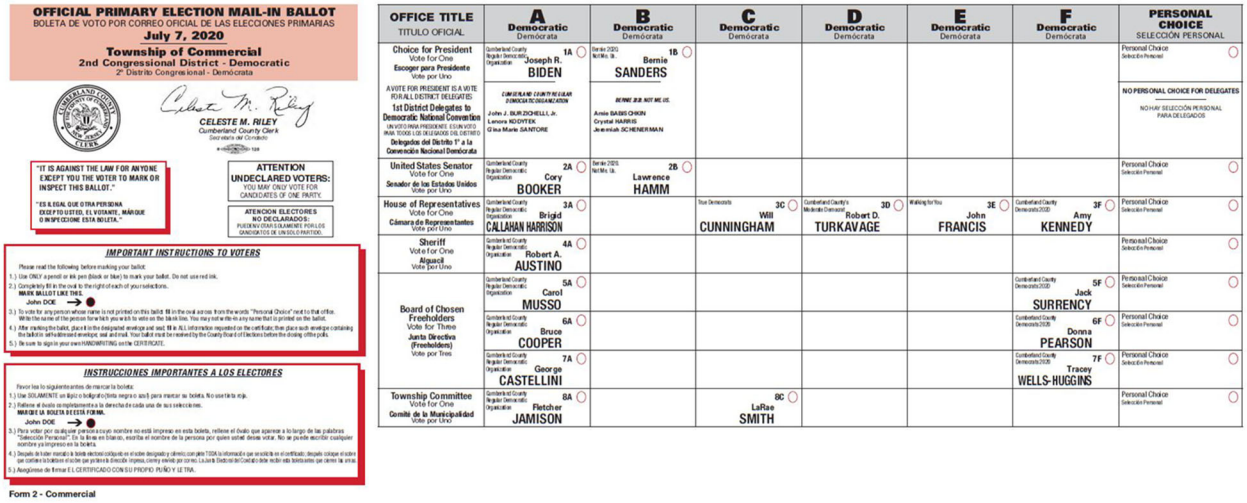

Figure 1: The New Jersey party column ballot design for primary elections. This example shows the ballot design for the 2020 Cumberland County Democratic Primary in New Jersey's Second Congressional District. This ballot is generally representative of ballot design in 19 out of 21 New Jersey counties.

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4. ANALYSIS

4.1: THE COUNTY LINE PROVIDES A COGNITIVE SHORTCUT

The county line system has features suggesting that it may give voters a mental shortcut which may drive their behavior. I will now describe features of human visual processing that may bias the choice made by voters presented with a party column ballot.

Voters may be influenced by cues that do not reach their conscious awareness. Therefore, their choice is not necessarily made freely. Biologically speaking, the brain is a survival machine that has been selected to get through life efficiently and maximize the odds of survival. As an adaptation to the speed and burdens of everyday life, mental shortcuts simplify the complexity of the world. Such a shortcut is termed a heuristic: a rule that works most of the time, but not always. Using heuristics, human decisions approximate rationality in many situations, but can go astray under particular circumstances.

Cognitive shortcuts can steer behavior. Social psychologists Susan Fiske and Shelley Taylor identified a guiding principle in how brains can be led astray and coined the phrase "cognitive miser" to encapsulate the idea that humans make judgments and choices that minimize mental effort. Susan T. Fiske and Shelley Taylor, *Social cognition* at 13 (2nd ed. 1991). They proposed that conserving mental effort—being a cognitive miser—can account for a variety of cognitive biases, including racial stereotyping, political polarization, and motivated reasoning.[4] In their model, mental resources are expended judiciously to serve any goal. This principle can account for observations in cognitive neuroscience, social psychology, the evolution of animal behavior, and behavioral economics. In each case, cognitive shortcuts can be a source of unintended bias.

4.1.1 THE COUNTY LINE CREATES A PATH FOR THE EYE AND THE BRAIN

A first step in identifying biased design is to apply basic principles of decision heuristics and visual neuroscience. The physical arrangement of candidate names on the county line may treat candidates unequally to a greater extent than that arising from a simple list. The presence of unusual geometric arrangements, which tend to guide the eye, may be taken as an indication of potential bias toward favored candidates and away from candidates who are not favored.

The geometric layout of a party column ballot may lead the voter's gaze. Like other visual primates, humans use the arrangement of objects to detect patterns and even make decisions. The brain's visual system is biased towards horizontal and vertical orientations relative to oblique orientations. R.J.W. Mansfield, *Neural Basis of Orientation Perception in Primate Vision*, 186 SCIENCE 1133, 1133–35 (1974). A bias that favors some candidates in the current ballot design may have its roots in typical visual experience in the U.S., as seen by cross-cultural comparison, for example, with Cree Indians, whose environments were not rich in vertical and horizontal lines. Robert C. Annis & Barrie Frost, *Human Visual Ecology and Orientation Anisotropies in Acuity*, 182 SCIENCE 729, 729–31 (1973).

The use of patterns to guide action is also well-known in the sciences and arts. Charles G. Gross & Marc H. Bornstein, *Left and Right in Science and Art*, 11 LEONARDO 29 (1978). For example, objects lined up on a canvas can guide the eye toward an emphasis point in a

[4] "Motivated reasoning" refers to a cognitive bias in which a person processes new information in a manner that is consistent with a pre-existing belief.

painting. Furthermore, "individuals typically enter a picture at the left foreground and proceed along a specified path or 'glance curve' into the depth of the picture and over to its right-hand side."

New Jersey's party column ballot for primary elections contains structures that guide the eye in ways that do not allow equal treatment of all candidates. Most prominent is a column featuring not all candidates for one office, but one candidate for each office, with various opponents displayed elsewhere. Brett Pugach, *The County Line: The Law and Politics of Ballot Positioning in New Jersey*, 72 RUTGERS U.L. REV. 629, 655 (2020). The salience of this structure is known as the "weight of the line."

4.1.2 THE COUNTY LINE MAY DRIVE DECISION HEURISTICS AND VOTER CHOICE

The foregoing well-known features of visual processing make it easier for a voter to make choices listed first, clustered near one another, and/or arranged in an orderly line. Such preferences can be independent of the merits of candidates, driven by subtle encouragement of one choice over others. In this way, the design of a party column ballot nudges the voter toward one choice over others, much like a classic card force in which a subject can be induced to pick a particular card from a presented deck. In this way even the most intelligent of voters can be led astray.

How people access, process, and integrate shortcuts into their decision-making process also influence voting behavior. Scholars have shown that the ease or difficulty of finding particular cues and their relative prominence can affect the nature and quality of the vote. Since the English language is read from left to right and top to bottom, a county line that appears near the left or top edge of a ballot may provide a strong, prominent cue. In other words, the weight of the line constitutes a simple visual shortcut.

The party column ballot combines several forms of visual misdirection which nudge voter behavior. It often contains an extreme version of a primacy effect, in which the first choice appears at the left of the ballot, coupled with the weight of the line, and separated by multiple blank spaces from later choices. In this case, the eyes must travel far to reach later choices. In addition, the scattershot placement of other candidates makes it difficult for the voter to match a candidate's name with the corresponding office or voting instructions.

Other biases may also distort a voter's decision-making process. When humans are presented with information, they are biased toward first impressions and resist change. In laboratory psychology experiments, participants given cues of similar validity at the start and in the middle of a decision scenario are more likely to select the primary cue. The bias toward early-presented cues is known as a primacy effect. The primacy effect, when it systematically favors one candidate over others, has been found to be a violation of voting rights. See Wang, Goldberg, and Rubin (2023) *Three Tests for Bias Arising From the Design of Primary Election Ballots in New Jersey*, 48 SETON HALL J. LEGIS. & PUB. POL'Y, 24, 45 (2023). McLain v. Meier, 637 F.2d 1159, 1166 n. 15 (8th Cir. 1980) ("[M]any studies

report a finding of some ballot advantage in the top position."). W. James Scott Jr., *California Ballot Position Statutes: An Unconstitutional Advantage to Incumbents*, 45 S. CAL. L. REV. 365 (1972).

4.2: INFLUENCE OF BALLOT DESIGN ON ELECTION OUTCOMES

Once it has been determined that display on a distinct row or column on a ballot is potentially problematic because of visually guided effects, a key question arises as to whether the visual weight of the county line has statistically significant effects on election outcomes.

To determine whether a facially suspect ballot design has meaningfully influenced election outcomes, it is desirable to have the outcomes of many elections conducted using that design. In the case of the New Jersey ballot line, such outcomes are available in two recent publications. I examined this data to determine the probability that the outcomes arose by chance. I performed statistical tests for two manifestations of such effects: (a) an unusually high success rate for candidates running on the line. (b) unusually large vote shares arising specifically from placement on the county line.

4.2.1 NATURAL VARIATION PROVIDES A WAY TO DISTINGUISH COUNTY-LINE EFFECTS FROM OTHER EFFECTS

The administration of New Jersey elections allows alternative hypotheses about ballot design to be tested using standard tools of statistics. New Jersey has twenty-one counties, which leads to variation in how elections are administered—and how ballots are designed. This creates what in the social sciences are called natural experiments. A natural experiment takes advantage of the fact that conditions may vary in a manner that allows the effects of particular features to be studied.

New Jersey county clerks administer elections and design ballots in cooperation with party committees, each of which has its own bylaws governing the endorsement process. Ballot designs may also vary. Thus, in the normal practice of election administration, the county line is determined by processes that vary across counties. Because of this variation, it is possible to compare the same candidate's performance in different counties or with different ballot designs.

One concern in testing the effects of ballot design is the importance of avoiding conflation of the consequences of ballot design with other causes. For example, endorsement by the political party apparatus may reflect advantages in "access to money, voter databases, field organizations, and other resources that may not be available to other candidates." Pugach, *supra* at 655. In this alternative narrative, better candidates receive party endorsements and resources, leading to better performance at the ballot box, regardless of the unfair impact that a ballot design may yield. In this report I will test this alternate hypothesis.

4.2.2 THE COUNTY LINE GIVES INCUMBENTS A SPECIAL ADVANTAGE FOR RE-NOMINATION

Existing officeholders who seek re-election to their seat have a presumptive advantage for re-nomination. Their incumbency comes with name recognition and standing connections to the community, party, and donors. This incumbent advantage makes a loss in the primary unlikely, but not impossible.

Despite their advantages, incumbent candidates may still vary in how they appear on the primary ballot. A candidate may fail to appear on the county line because the county party did not select them or if they were redistricted into the same district as another incumbent, in which case only one of the two incumbents could receive the county line. This variation creates the possibility of a rigorous statistical test of the effects of the county line.

Between 2003 and 2023, 1,033 incumbent New Jersey state legislators ran for re-election, of whom 228 faced opponents in the party primary. 209 incumbents ran in districts where they had the county line in every county in the district; of these, only 3 were defeated. Nineteen lost the line in at least one of the counties in their district; of these, 10 were defeated. Finally, at least 5 incumbents lost the county line and withdrew before the primary. Truly, not being on the line was consequential for New Jersey incumbents' political careers.

Intuitively, the two winning track records, 206 out of 209 incumbents fully on the line compared with 9 out of 19 incumbents that did not have the county line in all of their counties, seem quite different. Statistical science allows the possibility of quantifying this intuition with mathematical rigor.[5] For these two sets of track records, the probability that they came from a population with the same odds of re-nomination is less than 1 in 3 billion, as calculated by the Fisher exact test. In other words, if one were to combine all 228 incumbents and repeatedly pick 19 at random, one would have to do so over 3 billion times before it became likely that one would get 9 losers. Such a low probability, 0.0000000003,

[5] In statistical science, one can test a default hypothesis which should be accepted in the absence of contrary evidence. Such a default scenario is called a null hypothesis, and convincing evidence is necessary in order to rule it out. Hypothesis testing in statistics consists of calculating the probability that a set of observations arose under the null hypothesis; this probability is called a *p*-value. Smaller *p*-values indicate a surprising result that provides evidence against the null hypothesis. If the probability of the null hypothesis is sufficiently low (typically less than 0.05, *i.e.* 1 in 20), it is called statistically significant and one would tend to rule out the null hypothesis. The lower the *p*-value, the more surprised one would be to learn that the null hypothesis was true.

As an example of null hypothesis testing, imagine a fair six-sided die. Cast repeatedly, it would turn up each possible outcome about one time out of six. If a person were given another die and it came up with a particular outcome, for example a 6, with much higher frequency, he/she might form the suspicion that the die was loaded to bias the outcome. The pioneering statistician Ronald Fisher established a method to calculate the exact probability that these two dice are producing a 6 at different rates. Ronald A. Fisher, *Statistical methods for research workers* (5th ed. 1934). His invention, the Fisher exact test, is in wide use today. See VASSARSTATS, https://vassarstats.net/tab2x2.html. I used the Fisher exact test to compare the winning track records of New Jersey legislative incumbents.

is considered extremely statistically significant and is consistent with the interpretation that the county line is closely associated with the ability of incumbents to be renominated.

In an alternative explanation of these results, it may simply be that re-election is generally easy for incumbents. This idea too can be tested by comparing the re-election performance of New Jersey incumbents receiving the county line with legislative incumbents across the other forty-nine states. These incumbents provide a clear comparison group against which to measure the re-election performance of New Jersey legislators (see Table 1).

From 2010 to 2023, of over 34,000 primary contests nationally (other than New Jersey) in which incumbents ran for re-election, they lost 1,145 races, a failure rate of 3.37%. I compared this with the 1,014 New Jersey state legislative races where the incumbent was listed on every county line in their district that used a party column ballot, whether the incumbent was opposed or not. All but three were renominated, giving a failure rate of 0.30%, eleven times lower than incumbents nationwide. The probability that this difference arose by chance is less than 1 in 20 billion, in this case determined using the chi-square test.[6]

	Nationwide	N.J. on line
lost primary	1,145	3
won primary	>34,000	1,014
loss probability	3.37%	0.30%

Table 1. Probability of incumbent state legislators losing re-nomination from 2010 to 2023.

4.3 THE EFFECTS OF THE COUNTY LINE EXCEED THOSE OF CANDIDATE CHARACTERISTICS ALONE

I have demonstrated that incumbents have a statistically highly significant advantage that is associated with attaining the county line on the ballot. However, the possibility remains that incumbents may fail to get the county line for substantive reasons, which county committees may identify when screening candidates. For example, local party officials and activists will likely be aware of candidate quality, funding, and issue stands. In this explanation, voters might detect a candidate's weakness even without the county line mechanism.

This alternative explanation can be examined critically with another test based on the idea that each race is best compared to itself. In other words, it is helpful to compare outcomes

[6] The chi-square test (pronounced KAI-square) is recommended over the Fisher exact test for instances where there are more than 1,000 observations. See VASSARSTATS, *id.*

that occur naturally within individual races. Such within-race comparisons give a direct estimate of effects arising from conditions that vary from place to place. In these comparisons, the candidates are the same, ruling out the possibility that any differences arise from candidate strength.

4.3.1 NEW JERSEY U.S. HOUSE AND SENATE CANDIDATES RECEIVED AN AVERAGE ADVANTAGE OF 38 PERCENTAGE POINTS WHERE THEY WERE ON THE COUNTY LINE

An incumbent may have the line on one county's ballot but not in another county. This could happen for a variety of reasons. Different county committees may reach different decisions about who they wish to support, even if the candidates are the same, with the same policy positions, campaign budgets, and other characteristics. Or a candidate could win the endorsement of a county committee, but in a county where the ballot uses a conventional office-block ballot arrangement that does not have a county-line layout. Finally, during the COVID-19 pandemic, some mail ballots did not follow the same format as the in-person ballot. All of these circumstances, arising for different reasons, provide a way to measure the effect of the ballot line. Averaging across a large number of districts and candidates helps to rule out individual factors, such as a candidate residing in one county, spending more time there, or advertising more.

Between-county comparisons have arisen repeatedly in primary elections for federal office. In published election data spanning two decades, from 2002 to 2022, 45 U.S. House or U.S. Senate primaries had contests in which different candidates received the county line in different counties. The differences arising are illustrated in Figure 2.

Every candidate received a higher vote share when they were on the line than when they were not. The smallest performance difference for those 45 contests was 13 percentage points and the largest was 79 percentage points, with an average difference of 38 percentage points. The probability that such a difference occurred by chance (*i.e.*, that it differed from an average of zero) is less than 1 in 1 quintillion (1 billionth of a billionth, or 1 in 1,000,000,000,000,000,000).[7]

[7] Statistical evaluation of numerical averages is often done using a tool called Student's *t*-test. Student's *t*-test generally asks whether an average differs from another average or from zero. It was originally developed as a means of quality control in beverage manufacture by William Sealy Gosset of the Guinness Brewing Company working under a pseudonym. Student, *The Probable Error of a Mean*, Biometrika 6(1), 1-25 (1908).

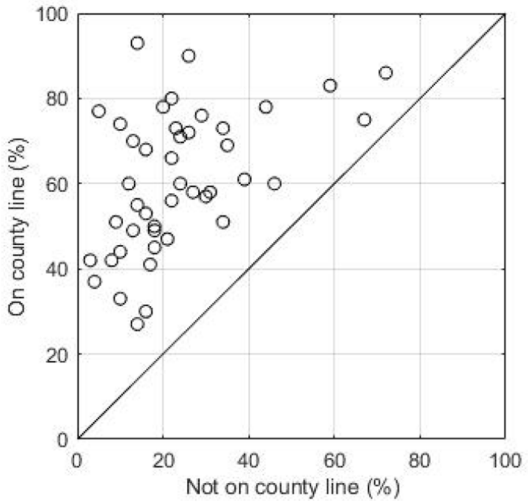

Figure 2: The advantage of being on the county line in 2002-2022 federal U.S. House and Senate elections in New Jersey. The horizontal axis represents a candidate's vote share when not on the county line, and the vertical axis shows the vote share when on the line. The diagonal line represents equality. All the candidates received a higher voter share if they were on the county line than if they were not.

4.3.2 FOR NONINCUMBENT CANDIDATES, THE COUNTY LINE CONFERS AN AVERAGE ADDITIONAL 17 PERCENTAGE POINTS OVER PARTY ENDORSEMENT ALONE

It could be claimed that the county line simply reflects an endorsement by a county's political party. In this telling, it is the endorsement that confers the advantage, not the physical arrangement of the ballot. Addressing this claim is of critical importance, since it distinguishes a possibility that indicates an improper behavioral nudge (*i.e.* the ballot design drives behavior) from protected political speech (*i.e.* a party makes an endorsement, and voters respond favorably to the endorsement) .

To address this alternative possibility, I evaluated the contribution that arises specifically from the county line combined with party endorsement, as opposed to the effects of the party endorsement alone. Making this comparison requires situations in which a candidate receives the party's endorsement, but different counties do or do not use a party column ballot design. The difference provides a measure of the specific effect of the county line.

Professor Julia Sass Rubin's factual research has revealed a number of primary candidates who in some counties received both an endorsement and the county line, while in other counties received an endorsement but no county line. See Rubin expert report, Figure 16 at pages 19-20. Incumbents are indicated below in parenthesis.

For U.S. Senate, data for county-line-over-non-county-line performance are available for five contests between 2012 and 2020: Joe Kyrillos (2012, Republican, 32 percentage points); Bob Hugin (2018, Republican, 15 percentage points); Rikin Mehta (2020,

Republican, 16 percentage points); Bob Menendez (2018, Democratic incumbent, 15 points); and Cory Booker (2020, Democratic incumbent, 3 percentage points). Notably, in two of these races, the eventual nominee did not receive a majority of the primary vote in counties where a party column ballot was not used: Joe Kyrillos in 2012, and Bob Menendez in 2018.

For governor, data are available for five contests between 2013 and 2021: Chris Christie (2013, Republican incumbent, 4 percentage points); Barbara Buono (2013, Democrat, 8 percentage points); Kim Guadagno (2017, Republican, 15 percentage points); Phil Murphy (2017, Democrat, 12 percentage points); and Jack Ciattarelli (2021, Republican, 11 percentage points). In three of these races, the eventual nominee again did not receive a majority of the primary vote in counties where a party column ballot was not used: Kim Guadagno in 2017, Phil Murphy in 2017, and Jack Ciattarelli in 2021.

For U.S. House, data are available for 27 contests between 2012 and 2022.[8] As representative examples, here I list 2020, when an incumbent president, the U.S. Senate, and the U.S. House were all on the ballot, conditions that all hold in 2024. Endorsement-without-county-line occurred for five candidates in 2020: Brigid Callahan Harrison (Democratic candidate, Second District, 24 percentage points), Jeff Van Drew (Republican incumbent candidate, Second District, 10 percentage points), Thomas Kean, Jr. (Republican candidate, Seventh District, 13 percentage points), Bill Pascrell (Democratic incumbent candidate, Ninth District, -7 percentage points), and Josh Gottheimer (Democratic incumbent candidate, Fifth District, 4 percentage points). In two of the 27 races, the eventual nominee did not receive a majority of the primary vote in counties where a party column ballot was not used: David Cole in 2016 and Jeff Van Drew in 2018, in each case running as Democrats in the Second Congressional District.

Combining these instances for governor, U.S. Senate, and U.S. House, it is possible to measure the overall effects of county-line placement. The overall difference averaged 12.2 percentage points across 37 contests, with a larger vote share for county-line placement in 35 out of 37 instances. This average difference differs from zero with extreme statistical significance, occurring by chance 1 in 1.9 million times (a probability of 0.00000051). The difference is consistent with the hypothesis that candidates derive a specific benefit from being on the county line that is separate from party endorsement.

If county line placement provides a nudge to voters, placement on the county line could be of greater benefit to candidates who do not have the advantages of incumbency. This was indeed the case. The difference for non-incumbents averaged 17.1 percentage points across 20 contests, larger than the difference for all contests combined. The 17.1-point average differs from zero with extreme statistical significance, occurring by chance 1 in 5.2 million

[8] For brevity, only values for U.S. House candidates for the 2020 election are listed here. For other values see Prof. Rubin's expert report. For this report I used data for all 27 U.S. House contests.

times (a probability of 0.00000019). Therefore, the evidence indicates that county endorsements lead to a strong advantage for nonincumbents.

Conversely, many incumbents may have advantages that tend to outweigh or eclipse ballot effects. If so, then the benefit of county-line placement might be smaller for them. For incumbents, the average benefit was 6.5 percentage points across 17 contests. The 6.5-point average differs from zero with extreme statistical significance, occurring by chance less than 1 in 5,000 times (a probability of 0.00018). Therefore, the evidence indicates that county-line placement leads to an advantage for incumbents that, while smaller than for non-incumbents, is still statistically significant.

Finally, of particular relevance for the 2024 election is the case of nonincumbent candidates running for statewide office. This case is pertinent to Democrats Andy Kim and Tammy Murphy, two nonincumbent candidates who have begun to receive county-level party support in the U.S. Senate race. Combining the instances for governor and U.S. Senate candidates who were non-incumbents, the difference in vote share for county-line with party endorsement, compared with party endorsement alone, averaged 15.6 percentage points across 7 contests. This average differs from zero with extreme statistical significance, occurring by chance less than 1 in 1,000 times (a probability of 0.00091).

Taken together, these differences provide an estimate of the advantage arising from the county line that comes on top of, and independent of, either the party endorsement or incumbency. The results indicate that the county-line system confers an advantage that is particularly large for nonincumbents.

4.3.3 BALLOT PRIMACY EFFECTS, WHICH HAVE BEEN FOUND TO BE UNCONSTITUTIONAL, ARE SMALLER THAN THE ADVANTAGE OF THE COUNTY LINE IN NEW JERSEY

Courts nationwide have cabined laws that produce ballot primacy effects: they have struck down laws granting the first position on the ballot to the first person alphabetically, to the incumbent, and to candidates belonging to a specific party. In order to avoid generating a primacy effect that consistently benefits one candidate, many states allocate candidate order randomly or by rotating the order to list each name first on the ballot the same number of times. It may therefore be of interest to compare the size of the effects of the county line with previous studies of the effects of ballot primacy.

Ballot primacy effects are well-measured throughout the United States. Jacobson v. Lee, 411 F. Supp. 3d 1249, 1269 (N.D. Fla. 2019), *vacated*, Jacobson v. Fla. Sec'y, 957 F.3d 1193 (11th Cir. 2020); for a review of the literature on primacy effects, see expert report of Jon Krosnick, ECF No. 112-1. Candidates listed first on a list outperform later-listed candidates by 1 to 5 percentage points, enough to swing a close election. In the 1992 Ohio elections, the candidate listed first had a vote share that was 2.5 percentage points higher on average. A study examining twenty-four years' worth of California elections found that

in nonpartisan primaries, being listed first led to a 3 percentage-point increase in vote share. Daniel E. Ho & Kosuke Imai, *Estimating Causal Effects of Ballot Order from a Randomized Natural Experiment: The California Alphabet Lottery, 1978-2002*, 72 PUB. OP. Q. 216, 232 tbl.4, 234-35 tbl.5 (2008). In California, the further down a ballot a candidate appeared, the larger the advantage (compared to the expected vote share) a candidate listed first obtained. This "statistical study verifies the presence of a positional bias in virtually all California elections . . . [the results] indicate that one can attribute at least a five percent[age point] increase in the first listed candidate's vote total to a positional bias." W. James Scott Jr., *California Ballot Position Statutes: An Unconstitutional Advantage to Incumbents*, 45 S. CAL. L. REV. 365, 376 (1972). This effect holds across general elections and primaries throughout the United States, and minor parties and nonpartisan candidates experienced statistically significant changes in vote share by being listed first. In primaries, all candidates experienced significant boosts, as much as 6.5 percentage points in the Libertarian primary.

When candidate names were randomized in a New York City primary, the candidate listed first won in 71 of 79 precincts. Jonathan G. Koppell & Jennifer Steen, *The Effects of Ballot Position on Election Outcomes*, 66 J. POL. 267, 272 (2004), In the statewide senatorial race, the candidate listed first had an advantage of 1.8 percentage points on average. Other statewide candidates had advantages ranging from 1.6 to 2.8 percentage points. Further down the ballot, being listed first gave candidates advantages of up to 11.4 percentage points, an exceptionally large advantage that may have arisen from the low information about the race available to voters. Based on these examples and many others, the typical ballot primacy effect is a 1 to 5 percentage point advantage for races high on the ticket. Accordingly, I conclude that the advantage arising from ballot primacy effects in those studies is far exceeded by the effect of the county line, under a variety of circumstances.

5. CONCLUSIONS

I find that the ballot design widely used for New Jersey primaries has four substantial features.

First, the New Jersey ballot design contains elements that are unnecessary for the efficient conduct of elections. Cognitive science and design principles suggest that these elements would tend to unduly favor one or more candidates appearing on the county line.

Second, the ballot design leads to a pattern of outcomes that deviates from expectations based on other designs at a statistically significant level. Compared with incumbents running for election nationwide, New Jersey legislative incumbents on the county line have an advantage for winning that has less than a 1 in 1 billion probability of arising by chance.

Third, the bias arising from New Jersey ballot's county line is associated with an advantage in U.S. House and U.S. Senate races that averages 38 points in favor of candidates on the county line, compared with the opponent gaining the county line.

Fourth, for the particular instance of nonincumbents running in a primary for governor, U.S. Senate, or U.S. House where one candidate has the party endorsement, the candidate having the county line and the party endorsement gains an additional 17 points above having the party endorsement alone. This comparison is of relevance to this year's U.S. Senate and U.S. House elections, in which numerous nonincumbents are running and will in all likelihood receive party endorsements.

Based on principles of neuroscience and statistical testing, I conclude that the foregoing results are consistent with the explanation that the physical arrangement of candidate names on the county line acts as a powerful force to steer voter behavior toward choices made by the county party chair, and that this effect goes beyond the effect of party endorsement. The county-line ballot design for selecting party nominees therefore imposes a cognitive bias on even the most intelligent voter, distorting their ability to choose candidates freely.

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Scott Jr., W.J. (1972). California ballot position statutes: An unconstitutional advantage to incumbents. *Southern California Law Review*, 45(2), 365-399.

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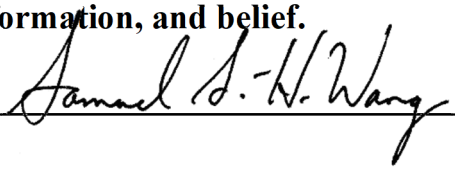
Wang, S.S.-H., Goldberg, H., & Rubin, J.S. (2023). Three tests for bias arising from the design of primary election ballots in New Jersey. *Seton Hall Journal of Legislation and Public Policy*, 48, 24-47.

I certify that the foregoing analysis and opinions are based on my education, training, and expertise. Further, I verify that the foregoing analysis is accurate to my knowledge, information, and belief.

Signature  **Date: February 13, 2024**

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Appointments

2022-	Affiliate, Center for Statistics and Machine Learning, Princeton University
2019-	Professor, Neuroscience, Princeton University Affiliate, Department of Molecular Biology
2015-	Associate, Program in Law and Public Affairs Associate, Center for Information Technology Policy Affiliate, Program in Cognitive Science Affiliate, Program in Quantitative and Computational Biology
2015-2019	Professor, Neuroscience and Molecular Biology, Princeton University
2006-2015	Associate Professor, Dept. Molecular Biology and Neuroscience Institute
2000-2006	Assistant Professor, Department of Molecular Biology, Princeton University
1997-1999	Postdoctoral Member of Technical Staff, Biological Computation Research Department, Bell Labs Lucent Technologies
1995-1996	Congressional Science Fellow, Senate Committee on Labor and Human Resources

1994-1995, 1996-1997 Postdoctoral fellow, Duke University

Education

1994	Ph.D., Neurosciences, Stanford University (advisor: Stuart H. Thompson)
1986	B.S. with honor, Physics, California Institute of Technology

Research interests

1) Neuroscience of sensory learning, development, and autism
2) Computational analysis of electoral systems and representation

Honors and awards

1986	Tau Beta Pi, national engineering honor fraternity
1993	Grass Fellow, Marine Biological Laboratory, Woods Hole, Massachusetts
2000-2002	Alfred P. Sloan Research Fellowship

2000-2002	Rita Allen Foundation Scholar
2004-2009	W.M. Keck Distinguished Young Scholar in Medical Research
2004-2009	National Science Foundation Career Development Award
2006	Fellow in Residence, Rockefeller Foundation, Bellagio, Italy
2009	AAAS/Subaru SB&F Prize for Excellence in Science Books
2012	Eden Autism Services – Emily Cavaliere Puzio and Frank Mauro Puzio Fellow
2016	Common Cause Gerrymandering Standard Writing Contest (*second prize*)
2018	Common Cause Gerrymandering Standard Writing Contest (*first prize*)

Professional society memberships

1986-	Society for Neuroscience, member
2000-	American Association for the Advancement of Science, member

Electoral and Legal Scholarship

(Neuroscience scholarship starts on page 9)

ARTICLES

S.S.-H. Wang (2015) Origins of Presidential poll aggregation: A perspective from 2004 to 2012. ***International Journal of Forecasting***, 31:898-909.

S.S.-H. Wang (2016) Three tests for practical evaluation of partisan gerrymandering. 68 ***Stanford Law Review***, 1263-1321.

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S. Wang (2016) Q&A on neuroscience, elections, and statistics. ***Neuron***, 92:290-293.

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S.S.-H. Wang, B.A. Remlinger, and B. Williams (2018) An antidote for gobbledygook: organizing the judge's partisan gerrymandering toolkit into a two-part framework. ***Election Law Journal***, 17:302-314.

W.T. Adler and S.S.-H. Wang (2018) Response to Cho and Liu, "Sampling from complicated and unknown distributions: Monte Carlo and Markov chain Monte Carlo methods for redistricting." ***Physica A***, 516:591-593.

S.S.-H. Wang, R.F. Ober Jr., and B. Williams. Laboratories of democracy reform: state constitutions and partisan gerrymandering (2019) ***University of Pennsylvania Journal of Constitutional Law***, 22(1)203-289.

S.S.-H. Wang and J.S. Canter (2020) The best laid plans: unintended consequences of the American Presidential selection system. ***Harvard Law and Policy Review***, 15:401-428.

S.S.-H. Wang, J.R. Cervas, B. Grofman, and K. Lipsitz (2021) A systems framework for remedying dysfunction in U.S. democracy. ***Proceedings of the National Academy of Sciences USA***, 118(50), e2102154118 (cover article).

R.F. Ober Jr., S.S.-H. Wang, and A. Barden (2021) Up by their bootstraps: will a new Supreme Court let legislatures bypass governors over redistricting? ***Albany Law Review: State Constitutional Commentary***, 84(4):783-815.

S.J. Chen. S.S.-H. Wang, B. Grofman, R.F. Ober, Jr., K.T. Barnes, and J.R. Cervas (2022) Turning communities of interest into a rigorous standard for fair districting, ***Stanford Journal of Civil Rights and Civil Liberties***, Volume XIII, Issue 1, 101-189.

S.S.-H. Wang and R.F. Ober Jr. (2023) All pain, whose gain? A fifty-state analysis of the independent state legislature doctrine for redistricting. ***University of New Hampshire Law Review***, 21(2), 495-521.

S.S.-H. Wang, H. Goldberg, and J. Sass Rubin (2023) Three tests for bias arising from the design of primary election ballots in New Jersey. ***Seton Hall Journal of Legislation and Public Policy***, . 48(1), 24-47.

Working paper from conference

Samuel S.-H. Wang (2019) A Bug in Democracy: Mythical and True Flaws in the Electoral College. Panel on the Electoral College organized by Rick Hasen and Bruce Cain. American Political Science Association meeting, Washington, D.C.

U.S. Supreme Court, Federal, and State Amicus Briefs

Brief of Samuel S. Wang, Ph.D., in re Wesley W. Harris, et al., Appellants v. Arizona Independent Redistricting Commission, et al. in Support of Appellees, 2015-16 term, No. 14-232.

Brief of Heather K. Gerken, Jonathan N. Katz, Gary King, Larry J. Sabato, and Samuel S.-H. Wang as amici curiae in support of appellees, Beverly R. Gill, et al., Appellants, v. William Whitford et al., 2017-18 term, No. 16-1161. **(cited in decision)**

Brief of Wesley Pegden, Jonathan Rodden, and Samuel S.-H. Wang as amici curiae in support of appellees, Robert A. Rucho, et al., Appellants, v. Common Cause et al., 2018-19 term, No. 18-422. **(cited in decision)**

Brief of the Princeton Electoral Innovation Laboratory as amicus curiae in support of defendants, 1:20-cv-00257-Lew Hagopian et al v. Dunlap et al. regarding ranked-choice voting elections in Maine. August 5, 2020. **(cited in decision)**

Brief of amici curiae Dr. Jonathan Cervas, Paul Mitchell, Dr. Samuel S.-H. Wang, Roderick Kennedy, Election Reformers Network, Common Cause New Mexico, and League of Women Voters New Mexico in support of neither party, No. D-506-CV-2022-00041, Republican Party of New Mexico v. Oliver regarding partisan gerrymandering of congressional map in New Mexico. August 14, 2023.

Advisory Roles

1995-1996	Legislative assistant, Rep. Lloyd Doggett (TX). Advised on matters coming before the House Science Committee; energy; and environment issues.
1996	Legislative fellow, Senator Edward M. Kennedy (MA). Advised Senate Committee on Labor and Human Resources on higher education, research policy, and K-12 education technology issues. Reauthorization of the National Science Foundation and coordination of NetDay96, a day of wiring Massachusetts schools to the Internet.

2010-present	Board of Directors, Rita Allen Foundation
2015-2022	Member, New Jersey Governor's Council for Medical Research and Treatment of Autism. Appointed by Governor Chris Christie (NJ).
2017	Contributing editor, *The American Prospect*
2021-present	Advisory Board, Unite America
2021	Technical advisor to chair of New Jersey Redistricting Commission
2022	Technical advisor to tiebreaking 11th commissioner, New Jersey Apportionment Commission
2022	Assistant to Special Masters, North Carolina redistricting cases of *Harper v. Hall* and *North Carolina League of Conservation Voters v. Hall*

GRANT AND FELLOWSHIP SUPPORT

2017-2019 Educational Ventures, Inc.: New Horizons for Gerrymandering Prevention

2018-2019 The Eric and Wendy Schmidt Fund for Strategic Innovation: Seeding the Gerrymandering DataHub

2019 Marilyn J. Simons Foundation, support for research and analysis to support redistricting reform

2020-2021 The Eric and Wendy Schmidt Fund for Strategic Innovation: Using Data and Tools to Democratize the 2021 Redistricting Process

2020-2022 Arnold Ventures: An Electoral Innovation Initiative at Princeton University and Open Primaries

2023-2024 Princeton Catalysis Initiative: Modeling-Based Approaches to a Science of Democracy Reform. Co-investigator: Simon A. Levin.

GENERAL-INTEREST WRITINGS AND OUTREACH

Public projects

Founder, Princeton Election Consortium, http://election.princeton.edu. 2004-present. Over 19 million visits total. During election season, this site has accounted for approximately one-fourth of web traffic to Princeton University.

Founder, Princeton Gerrymandering Project, http://gerrymander.princeton.edu. 2017-present. Providing data and information resources on partisan gerrymandering.

Founder, OpenPrecincts, http://openprecincts.org. 2019. A crowdsourced database of precinct and election data for public participation in redistricting in all fifty states, the District of Columbia, and Puerto Rico. A product of the Princeton Gerrymandering Project.

Faculty founder, Representable, http://representable.org. 2019-2022 Princeton University, 2022- Center for Urban Research. A student-initiated software tool to give anyone the ability to report their communities of interest to a validated map database, for giving direct feedback to redistricting authorities. A product of the Representable team and the Princeton Gerrymandering Project.

Co-founder, Electoral Innovation Lab. 2020-2022 at Princeton University; became independent in 2022. This umbrella organization encompasses previous democracy reform activities under a broader mission of building a science of democracy reforms using social, cognitive, and computational science.

Independent reports

A commissioner's guide to redistricting in Michigan (ed.). By graduate students of the Woodrow Wilson School of Public and International Affairs (now the Princeton School of Public and International Affairs). February 2019.

Improving New Jersey's legislative apportionment process: recommendations to increase transparency, accountability, and representation. Special report by Samuel Wang, Yurij Rudensky, Patrick Murray, Brigid Callahan Harrison, Ronald Chen, and Ben Williams. July 2019.

A citizen's guide to redistricting in Ohio (ed.). By the Electoral Innovation Lab, report EIL-2023-002. September 2023.

Podcast

6/2016-5/2022 Princeton School of Public and International Affairs (formerly the Woodrow Wilson School) weekly podcast Politics And Polls. Co-hosted with Julian Zelizer.

News Analysis

Contributions on data science and elections to *Washington Post, New York Daily News, Los Angeles Times, Politico, The New Yorker.com, The New Republic, The American Prospect, The Atlantic,* and *the Columbia Journalism Review*. 2008-2020.

Fixing Bugs In Democracy, an online interview series, Spring-Summer 2020.

The great gerrymander of 2012. *New York Times*, February 3, 2013, page SR1.

Sam Wang and Benjamin C. Campbell: Mr. Bayes goes to Washington: a review of *The Signal and The Noise* by Nate Silver. *Science*, February 15, 2013, 339:758-759.

Let math save our democracy. *New York Times,* December 6, 2015, page SR6.

GOP nomination rules tilt the playing field toward Donald Trump. *The American Prospect*, January 14, 2016.

The hardened divide in American politics. *The American Prospect,* Fall 2016, 12-13.

Why Trump stays afloat. *New York Times*, October 30, 2016.

Can math stop partisan gerrymandering? *Los Angeles Times,* May 5, 2017 (with Brian Remlinger).

A manageable federalist approach to partisan gerrymandering. *Election Law Blog*, September 4, 2017. http://electionlawblog.org/?p=94580

Slaying the partisan gerrymander. *The American Prospect*, Fall 2017 (with Brian Remlinger).

Can open data save gerrymandering reform? *The American Prospect*, June 25, 2018 (with Ben Williams and John O'Neill).

The states are now the best route to gerrymandering reform. *The American Prospect*, July 16, 2018 (with Ben Williams and Rick Ober).

Lawmakers should fix inequitable district lines (concerning open data in Bethune-Hill Virginia districts). *The Virginian-Pilot*, August 30, 2018 (with Ben Williams and Will Adler).

Why North Carolina Democrats should fight gerrymandering using state law. *Washington Post*, September 4, 2018 (with Rick Ober).

The long-term solution to voter suppression. *The Atlantic,* October 31, 2018.

Partisan gerrymandering, still going strong (letter). *The Economist,* January 19, 2019.

Gerrymandering, not geography. *The Atlantic*, March 26, 2019.

If the Supreme Court won't prevent gerrymandering, who will? *New York Times,* July 14, 2019.

In redistricting, algorithms can't replace communities. *Raleigh News and Observer,* December 2, 2019 (with Jason Rhode and Hope Johnson).

Unchecked, COVID-19 could kill more than 50,000 in New Jersey. *NJ.com*, *Newark Star-Ledger* and *Trenton Times*, March 25, 2020. (with Sebastian Seung and Shirley Tilghman; co-signed by Martin Blaser, Bryan Grenfell, Jim Kim, Simon Levin, Jessica Metcalf, Olga Troyanskaya, and Roy Vagelos)

Bernie Sanders's parting gift to Wisconsin voters may last for a decade. *The Hill*, April 11, 2020.

Our polling trauma. *Columbia Journalism Review* magazine, Summer 2020, 16-18.

Virginia should lead the way on redistricting reform. *Virginia Mercury*, September 16, 2020. https://www.virginiamercury.com/2020/09/16/virginia-should-lead-the-way-on-redistricting-reform/ (with Aaron Barden and Jason Rhode).

Electoral math and the new Gilded Age. Symposium on Jack M. Balkin, The Cycles of Constitutional Time (Oxford University Press, 2020). Balkinization blog, balkin.blogspot.com, September 24, 2020.

Constitutional rot: a total eclipse, or a mistuned clockwork? Symposium on Jack M. Balkin, The Cycles of Constitutional Time (Oxford University Press, 2020). Balkinization blog, balkin.blogspot.com, September 25, 2020.

The filibuster and the zone of legislative death. *The Atlantic,* April 20, 2021 https://www.theatlantic.com/ideas/archive/2021/04/zone-legislative-death/618754/ (with Ari Goldbloom-Helzner).

Reapportionment's hidden surprises for 2022. *The Hill,* May 1, 2021 https://thehill.com/opinion/campaign/551306-reapportionments-hidden-surprises-for-2022 (with Zachariah Sippy).

The GOP scared Latinos from the census. Now that may cost the party red seats. *Washington Post,* May 1, 2021 https://www.washingtonpost.com/outlook/2021/05/01/hispanics-census-undercount-house-seats/ (with Jonathan Cervas).

Remaining unvaccinated in public should be considered as bad as drunken driving. *Washington Post,* September 14, 2021 https://www.washingtonpost.com/opinions/2021/09/15/remaining-unvaccinated-public-should-be-considered-bad-drunken-driving (with Leana Wen).

Opinion: Virginia has some of the fairest district maps in the country. Here's why. *Washington Post,* January 13, 2022 https://www.washingtonpost.com/opinions/2022/01/13/virginia-has-some-fairest-district-maps-country-heres-why/

Opinion: Republicans' Supreme Court argument on redistricting could backfire. *Washington Post,* December 1, 2022 https://www.washingtonpost.com/opinions/2022/12/01/gop-argument-redistricting-backfire/

INVITED SEMINARS

2013 National Academy of Sciences, 150th Annual Meeting, break-out session on The New Science Of Elections, Washington, DC (chair: Douglas Massey).

2013 Opening symposium, Quantitative Collaborative program, College of Arts and Sciences, University of Virginia, Charlottesville, VA.

2013 Roundtable on elections and public opinion, CENTRA Technology, Arlington, VA.

2014 Tracking national elections with high time resolution. American Politics Research Seminar, Princeton University, Princeton, NJ.

2016 Stanford Law Review symposium on the Law of Democracy and the 2016 Election, Stanford Law School, Stanford, CA.

2016 Partisan gerrymandering convening, Brennan Center for Justice, NYU, New York, NY.

2016 Detecting and remedying partisan gerrymandering. American Politics Research Seminar, Princeton University, Princeton, NJ.

2016 Workshop on automatic voter registration, Brennan Center for Justice, New York, NY.

2016 D.E. Shaw Company, New York, NY.

2017 Symposium on partisan gerrymandering, Duke University Law School, Durham, NC.

2017 Quantitative Theory and Methods Institute (social sciences), Emory University, Atlanta, GA.

2018 Seminar on partisan gerrymandering, Columbia University Medical Center, New York, NY.

2012-2017 Annual presentation to fellows, Program in Law and Public Affairs, Princeton University, Princeton, NJ.

2018 Partisan gerrymandering convening, Brennan Center for Justice, NYU, New York, NY.

2018 Hot topics in election law - redistricting and recent Supreme Court decisions, New Jersey Institute for Continuing Legal Education, New Brunswick, NJ

2018 Caltech, Founders' Night, keynote lecture, Pasadena, CA.

2018 Science on Saturdays lecture, Princeton Plasma Physics Laboratory, Princeton, NJ.

2018 Paul D. Bartlett Lecture, Linda Hall Science and Technology Library, Kansas City, MO.

2019 Panel on the Electoral College: Open Questions, Paths Forward. Harvard Law School, Cambridge, MA.

2021 Statistics, redistricting, and gerrymandering. Berkeley Judicial Center, Berkeley, CA.

2022 Panel on redistricting reform. American Bar Association.

2022 Law @ Princeton retreat, Princeton University Center for Human Values.

2022 Symposium on contemporary issues in election law, University of New Hampshire Law School, Concord, NH.

INVITED PUBLIC TALKS

2016 The November election. SciCafe, American Museum of Natural History, New York, NY.

2016 (keynote) Lecture on election analysis, Strata/Hadoop conference, New York, NY.

2016 Public lecture associated with the 2016 U.S. Vice-Presidential debate, Longwood University, Farmville, VA.

2016 The November election (with Landon Jones). Princeton Public Library, Princeton, NJ.

2017 Yale CEO Summit, New York, NY.

2017 Public lecture on statistics and elections, Lafayette College, Easton, PA.

2017 Statistical inequities of the Electoral College. Stanford Law School, Stanford, CA.

2017 (keynote) Presentation on statistical inequities of the Electoral College. Making Every Vote Count, National Press Club, Washington, DC.

2018 Nassau Club, Princeton, NJ.

2018 Present Day Club, Princeton, NJ.

2018 Princeton Bar Association, Princeton, NJ.

2019 Panel on redistricting policy organized by League of Women Voters, Maeder Hall, Princeton University, Princeton, NJ.

2019 Reason, Reform, and Redistricting conference at Center for Political Leadership, Innovation and Service, Duke University, Durham, NC.

2019 Unrig Summit, Nashville, TN.

2019 (keynote) Harvard CGA conference: The Geography of Redistricting. Cambridge, MA.

2020 Insight Lecture Series, Rockefeller University, New York, NY.

2020 Workshop on political polarization (co-organized by Simon Levin), Arizona State University, Tempe, AZ.

2020 Workshop on political polarization (co-organized by Simon Levin), Princeton University, Princeton, NJ.

2020 John G. Tower Center for Public Policy and International Affairs, Southern Methodist University, Dallas, TX.

2021 Panel on California Redistricting, California Constitution Center of UC Berkeley and Jack Citrin Center for Public Opinion Research, Berkeley, CA.

2021 Census Quality Review discussion on differential privacy protections in Census redistricting data, MALDEF/Asian Americans Advancing Justice.

2023 Town hall on redistricting and the 118th Congress with David Daley and Michael Li, FairDistrictsGA.

2023 Panel on gerrymandering with Yamiche Alcindor, Carol Anderson, and Evan Milligan, The Democracy Summit, at The Center for Democracy and Journalism, Howard University, Washington, DC.

2024 Insight Lecture Series, Rockefeller University, New York, NY.

Neuroscience Scholarship

FOR ALL PUBLICATIONS: >100 IN TOTAL; *h*-INDEX=49, *i*10-INDEX=91.
ORCID: 0000-0002-0490-9786
*The asterisked first two authors contributed equally to the published work.

S.S. Wang, G.A. Ricaurte, and S.J. Peroutka (1987) ^{3}H-3,4-methylenedioxymethamphetamine (MDMA; "Ecstasy") interactions with brain membranes and glass fiber filter paper. ***European Journal of Pharmacology*** 138:439-443.

S.S.-H. Wang, C.A. Mathis, and S.J. Peroutka (1988) R-2,5-Dimethoxy-4-^{77}bromoamphetamine (^{77}Br-R(–)-DOB), a novel radioligand [that] labels a 5-HT binding site subtype. ***Psychopharmacology (Berlin)*** 94:431-432.

S.J. Peroutka, A. Hamik, M.A. Harrington, C.A. Mathis, P.A. Pierce, and S.S.-H. Wang (1988) R-2,5-dimethoxy-4-^{77}bromoamphetamine [^{77}Br-R(–)DOB] labels a novel 5-hydroxytryptamine binding site in brain membranes. ***Molecular Pharmacology*** 34:537-542.

S.S. Wang and S.J. Peroutka (1989) Historical perspectives. In *The Serotonin Receptors*. (Ed. E. Sanders-Bush). Humana Press, pp. 3-20.

S.S.-H. Wang and S. Thompson (1992) A-type potassium channel clusters revealed using a new statistical analysis of loose patch data. ***Biophysical Journal***, 63:1018-1025.

C.A. Mathes, S.S.-H. Wang, H.M. Vargas, and S.H. Thompson (1992) Intracellular calcium release in N1E-115 neuroblastoma cells is mediated by the M1 muscarinic receptor subtype and is antagonized by McN-A-343. ***Brain Research*** 585:307-310.

S.S.-H. Wang, C.A. Mathes, and S.H. Thompson (1993) Membrane toxicity of the protein kinase C inhibitor calphostin A by a free-radical mechanism. ***Neuroscience Letters***, 157:25-28. (published in error a second time as 156:145-148)

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2002-2025 NIH R01 NS045193: Synaptic learning rules in the mammalian cerebellum (total: $1,958,688 over most recent 5-year renewal, 2020-2025)
2017-2022 NIH U19 NS104648: Mechanisms of neural circuit dynamics in working memory and decision-making (total: $15,346,730 over five years; shared among seven investigators)
2017-2022 NIH R01 MH115750: Cerebellar determinants of flexible and social behavior on rapid time scales in autism model mice. (S.W. is lead PI; co-investigators Joshua Shaevitz and Jonathan Pillow; total: $4,727,710 over 5 years)
2021-2024 NIH R01 MH128776: A web-based framework for multi-modal visualization and annotation of neuroanatomical data. (S.W. and David Kleinfeld, co-investigators; $1,194,702 over 3 years)

Past support:

1990 Lerner-Gray Grant in Marine Zoology
1989, 1991 Earl and Ethel Myers Fellowship in Marine Biology
1991-1993 NIH predoctoral National Research Service Award
1994-1997 NIH postdoctoral National Research Service Award
2001-2004 Whitehall Foundation grant
2006 Writing residency at Rockefeller Foundation Study Center, Bellagio, Italy
2005-2007 New Jersey Governor's Council on Autism Pilot Grant
2004-2008 Human Frontier Science Project grant (Principal Investigator)
2004-2009 National Science Foundation Career Development Award
2010 NIH shared instrumentation grant for multiphoton microscope (PI)
2009-2011 NIH Challenge Grant (Co-investigator; PI Lynn Enquist)
2009-2011 NIH Challenge Grant (Co-investigator; PI David Tank)
2011-2012 Simons Foundation Autism Research Initiative (SFARI) Explorer grant
2012-2013 David A. Gardner '69 Magic Project, Princeton Council of the Humanities
2012-2015 McKnight Technological Innovations in Neuroscience award
2014-2017 NIH U01 NS090541 BRAIN Initiative grant (Co-investigator; PI Carlos Brody)
2015-2017 NIH R21 NS092320: Transcending dynamic and kinetic limits for neuronal calcium sensing
2012-2018 Nancy Lurie Marks Family Foundation grant for autism research (Co-investigator with Mustafa Sahin and Wade Regehr)
2015-2018 NIH R21 EY026434: Use of calcium indicator proteins in spike counting mode (Co-investigator David DiGregorio)

ADVISORY ROLES, COMMUNITY OUTREACH, AND SERVICE

2021- Scientific Advisor, BlinkLab

2023* Gordon Research Conference on the Cerebellum, vice-chair (with Alanna Watt; will co-chair conference in 2025*). *Delayed from 2021 by pandemic.

2023 National Institute on Aging (NIA) workshop on cerebellar contributions to cognitive and affective functions. Session chair and co-organizer. September 12-13, 2023.

NIH standing study section membership

2010-2014 Molecular Neurogenetics (MNG) 2010-2014

NIH ad hoc review, 2007-present

2007 NIMH (Centers for Intervention Development and Applied Research, ZMH1 ERB-L)
2009 NIMH, National Institutes on Drug Abuse (CEBRA)
2013 Special Emphasis Panel for Brain Disorders and Clinical Neuroscience (BDCN) (ZRG1 BDCN-W (02))
2014 BRAIN Initiative: Transformative Approaches for Cell-Type Classification (ZMH1 ERB-M (06))
2014 BRAIN Initiative: Technologies for Large-scale Recording (ZNS1 SRB-G (77))
2015 Learning and Memory (LAM) study section, ad hoc
2015 Neuropharmacology (ZRG1 MDCN-R 94 S), ad hoc
2016 Special Emphasis Panel, ad hoc
2017/05 Special Emphasis Panel/Scientific Review Group ZNS1 SRB-G (13)
2018 BRAIN Initiative: Development and Validation of Novel Tools to Analyze Cell-Specific and Circuit-Specific Processes in the Brain (RFA MH-17-220)
2018 Transformative Research Award (TRA) Initiative panel
2019 BRAIN Initiative Novel Tools review
2020 BRAIN Initiative Novel Tools review (chair)
2020 BRAIN Initiative Cell Census Network (BICCN) review ZMH1 ERB-M (06) S
2021 BRAIN Initiative Novel Tools review (chair) 2021/05 ZMH1 ERB-M (06) R
2021 BRAIN Initiative Novel Tools review (chair) 2021/05 ZMH1 ERB-M (07) R
2021 BRAIN Initiative Pilot resources for brain cell type-specific access and manipulation across vertebrate species review (chair) 2021/08 ZMH1 ERB-Q (06) R
2022 BRAIN Initiative Novel Tools review (chair) 2022/05 ZMH1 ERB-Q (05) R
2022 NIH/VA Special Emphasis Panel 2022/08 ZRD1 MHBA-J (01)
2022 BRAIN Initiative diversity enhancement U24 review (chair) ZMH1 ERB-E (02)
2023 NIH Neurobiology of social information processing, ZRG1 IFCN-U (02) SEP
2023 BRAIN Initiative Novel Tools review (chair) 2023/05

Other reviewing

2021 NSF Major Research Instrumentation review panel
2023 Deutsche Forschungsgemeinschaft (DFG)

Journal peer reviewing: *Annals of the American Association of Geographers, Biological Psychiatry, Biophysical Journal, Brain Behavior and Evolution, Brain Research, Cell Reports, The Cerebellum, Cerebral Cortex, Chemical Biology, Current Biology, Election Law Journal, eLife, Frontiers in Neuroscience, J. Cell Biology, J. Comparative*

Neurology, J. Neurophysiology, J. Neuroscience, J. Neuroscience Methods, J. Physiology, Molecular and Cellular Neuroscience, Molecular Psychiatry, Nature, Nature Biotechnology, Nature Communications, Nature Methods, Nature Neuroscience, Nature Reviews Neuroscience, NeuroImage, Neuron, PLoS ONE, PNAS, Phil. Trans. Roy. Soc. B, and *Science*

U.S. PATENTS

Double-caged GABA: a novel light-activated probe as a neuroscience research tool. Application number 14/664,445, publication date September 14, 2015. Issued April 18, 2017 as U.S. Patent 9,625,448. D.D. Shi, M.F. Semmelhack, and S.S.-H. Wang.

Eyeblink conditioning using a mobile phone device. U.S. patent application pending. H.-J. Boele, S.S.-H. Wang. Application number 63/111,960.

System and method for remote neurobehavioral testing. U.S. patent application pending. H.-J. Boele, S.S.-H. Wang. Application number 18/036,009.

INVITED SEMINARS

Neuroscience meetings

1997 Southern California Optical Biology Users Group, University of California, Irvine, CA.
2000 Neural Information and Coding Meeting, Grindelwald, *Switzerland.*
2001 Gordon Research Conference on Calcium Signaling, Oxford University, Oxford, *England.*
2002 Workshop on Single Cell Computation, University College London, London, *England.*
2003 Workshop on Constraints in Neural Systems Design, Computational Neuroscience (CNS 2003) Meeting, Alicante, *Spain.*
2003 Banbury Workshop, Optimization and Constraints in the Evolution of Brain Design, Cold Spring Harbor Laboratory, Cold Spring Harbor, NY.
2003 Keck Foundation/National Academy of Sciences Futures Initiative, Decisions, Signals and Meaning in Biology, Chemistry, Physics and Engineering, Beckman Center, Irvine, CA. (no talk)
2004 Monte Verità Workshop on Spike-Timing Dependent Plasticity (STDP), Monte Verità, Ascona, *Switzerland.*
2004 Third Astrobiology Science Conference, NASA Ames Research Center, Moffett Field, CA.
2004 Symposium on Optical Methods in Neuroscience, Microscopy and Microanalysis meeting, Savannah, GA.
2004 Workshop on Optimization and Neural Coding, Institute for Theoretical Physics, Santa Barbara, CA.
2004 Meeting on Brain Development, National Alliance for Autism Research, Fort Lauderdale, FL. (no talk)
2005 Keck Foundation Annual Meeting, Los Angeles, CA. (also 2007, 2008, 2009, 2010)
2005 Invited retreat speaker, Department of Neurobiology, University of California, Los Angeles, CA.
2005 Mini-symposium on controlling neural function with light. Chair, Scott M. Thompson. Society for Neuroscience meeting, Washington, DC.
2005 Session moderator, Gordon Research Conference on Neuroethology. Chairs, Nicholas Strausfeld and Catherine Carr. Magdalen College, Oxford University, Oxford, *England.*
2005 US National Academy of Sciences Frontier of Science Symposium. Principles of Brain Design. Beckman Center, University of California, Irvine, CA.

2006 Rita Allen Foundation 30th Anniversary Symposium, Institute for Advanced Study, Princeton NJ.
2006 Human Frontier Science Project Awardees Annual Meeting, Institut Pasteur, Paris, *France*. (poster)
2007 Karger Workshop on brain evolution, Society for Neuroscience meeting, San Diego, CA.
2008 Mini-School and Workshop on Multiple Time Scales in the Dynamics of the Nervous System, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, *Italy*.
2008 Conference on Perceptual Learning, Motor Learning, and Automaticity, Netherlands Institute for Neuroscience, Amsterdam, *Netherlands*. (commemoration of the 200th anniversary of the Royal Netherlands Academy of Sciences)
2009 Banbury meeting on Searching for Principles Underlying Memory in Biological Systems, Cold Spring Harbor Laboratory, Cold Spring Harbor, NY.
2009 Meeting on Computational Cell Biology, Cold Spring Harbor Laboratory, Cold Spring Harbor, NY.
2009 Psi Chi Invited Speaker, Midwestern Psychological Association meeting, Chicago, IL.
2009 Society for Research on the Cerebellum, second annual meeting, Chicago, IL.
2010 McGovern Institute for Brain Research Symposium: Cells, circuits & behavior, MIT, Cambridge, MA.
2010 Symposium on Photons and Neurons, University of Rochester, Rochester, NY.
2010 Symposium on in vivo cerebellar imaging, Federation of European Neuroscience Societies, Amsterdam, *Netherlands*.
2010 Barcelona Cognition, Brain and Technology summer school, Barcelona, *Spain*.
2011 W.M. Keck Foundation Scholars Program final meeting, Beckman Center, Irvine, CA (co-organizer).
2011 Gordon Research Conference on Dendrites, Ventura Marriott, Ventura, CA.
2011 First Gordon Research Conference on the Cerebellum, Colby-Sawyer College, New London, NH.
2011 Boston Club meeting on cerebellum and autism, Nancy Lurie Marks Fdn., Wellesley, MA.
2012 Conference, Dendrites: Substrates for Information Processing, Janelia Conference, Ashburn, VA.
2012 Eden Foundation 18th Annual Princeton Lecture Series (keynote address), Princeton, NJ.
2012 Conference, Fluorescent Proteins and Biological Sensors III, Janelia Conference, Ashburn, VA (attendance cancelled due to Hurricane Sandy).
2013 McKnight Foundation Annual Meeting, Aspen, CO.
2013 Annual research symposium (keynote speaker), Delaware chapter, Society for Neuroscience, Newark, DE.
2014 McKnight Foundation Annual Meeting, Aspen, CO.
2014 Conference, Fluorescent Proteins and Biological Sensors IV, Janelia Conference, Ashburn, VA.
2014 Society for Neuroscience nanosymposium on cerebellum and autism (speaker and chair), Washington, DC.
2015 Keystone Conference on Pathways of Neurodevelopmental Disorders, Tahoe City, CA.
2015 BRAIN Initiative Investigator meeting, Bethesda, MD.
2016 McKnight Foundation Annual Meeting, Minneapolis, MN.
2016 Course on mouse methods in neuroscience, Jackson Laboratory, Bar Harbor, ME.
2017 Conference on cognition and psychiatric diseases, Brain and Spine Institute, Paris, *France*.
2017 Conference on procedural learning, Amsterdam, *Netherlands*.
2017 Gordon Research Conference on the Cerebellum, Bates College, Lewiston, ME.

2018 FENS Forum on the cognitive cerebellum, organized by M.E. Goldberg. Berlin, *Germany*.
2019 McKnight Foundation Neuroscience Conference, Aspen, CO.
2019 NIMH premeeting on New Perspectives on Cerebellar Function: Implications for Mental Health. Society for Neuroscience meeting, Chicago, IL.
2019 Minisymposium on the cognitive cerebellum, Society for Neuroscience meeting, Chicago, IL.
2022 Symposium: In Search of Causality: From Neuropsychiatric Genetics to Pathophysiology (panel chair). Simons Foundation for Autism Research Institute, New York Genome Institute, New York, NY.
2022 12th International Symposium of the Society for Research on the Cerebellum and Ataxias, Nanjing, *China*.
2022 NIMH Convergent Neuroscience meeting, UCSF Mission Bay, San Francisco, CA.
2022 Kavli Translational Neuroscience minisymposium, Rockefeller University, New York, NY.
2023 National Institute on Aging workshop on cerebellum, session organizer.

Research talks

1994 Department of Physiology, University of Colorado Health Sciences Center, Denver, CO.
1995 Department of Theoretical Physics, AT&T Bell Laboratories, Murray Hill, NJ.
1995 Laboratory of Theoretical and Physical Biology, National Institutes of Health, Bethesda, MD.
1999 Department of Neurobiology, Duke University Medical Center, Durham, NC.
1999 Department of Biomedical Engineering, Boston University, Boston, MA.
1999 Department of Developmental and Cell Biology, University of California, Irvine, CA.
1999 Department of Molecular Biology, Princeton University, Princeton, NJ.
1999 Department of Neurobiology and Behavior, University of California, Irvine, CA.
2000 Department of Neurology, Stanford University Medical Center, Stanford, CA.
2000 Department of Physiology, University College, London, *England*.
2000 Division of Neurophysiology, National Institute for Medical Research, London, *England*.
2000 Department of Biology, Morehouse College, Atlanta, GA.
2000 Max Planck Institute for Medical Research, Dept. Biomedical Optics, Heidelberg, *Germany*.
2000 Karolinska Institutet, Stockholm, *Sweden*.
2001 Sloan Center for Theoretical Neurobiology, Caltech, Pasadena, CA.
2001 Program in Neuroscience, Columbia University, New York, NY.
2001 Wyeth-Ayerst Research Laboratories, Princeton, NJ.
2002 Center for Neurobiology, Mount Sinai School of Medicine, New York, NY.
2002 Systems neuroscience seminar, Cold Spring Harbor Laboratory, Cold Spring Harbor, NY.
2002 Department of Physiology, New York Medical College, Albany, NY.
2003 Department of Physiology and Biophysics, University of Washington, Seattle, WA.
2003 Center for Cognitive Neuroscience, Duke University, Durham, NC.
2004 Baylor Medical College, Houston, TX. (Distinguished Neuroscientist Lecture Series)
2004 Max Planck Institute for Medical Research, Dept. Cell Physiology, Heidelberg, *Germany*.
2004 University of California, San Diego, CA.
2004 Salk Institute for Biological Studies, La Jolla, CA.
2004 Mathematical Biosciences Institute, Ohio State University, Columbus, OH.
2004 Neuroscience Program, University of Michigan, Ann Arbor, MI.
2004 Rowland Institute for Physics, Harvard University, Cambridge, MA.
2004 Department of Molecular and Cell Biology, Harvard University, Cambridge, MA.
2005 Center for Statistics in the Social Sciences, University of Washington, Seattle, WA.
2005 Department of Physiology and Biophysics, University of Washington, Seattle, WA.
2005 Department of Brain and Cognitive Sciences, MIT, Cambridge, MA.

2005 Learning and Memory Seminar, Dept. Neurobiology, UCLA, Los Angeles, CA.
2005 Redwood Neuroscience Institute, Menlo Park, CA.
2005 Department of Neurobiology, Stanford University School of Medicine, Stanford, CA.
2005 Hopkins Marine Station, Stanford University, Pacific Grove, CA.
2005 Neuroscience Colloquium, Brown University, Providence, RI.
2005 CIMA, University of Navarra, Pamplona, *Spain*.
2006 Biological Chemistry Seminar Series, University of Pennsylvania, Philadelphia, PA.
2006 Vollum Institute, Oregon Health Sciences University, Portland, OR.
2006 Interdepartmental science seminar series, Delaware State University, Dover, DE.
2006 Department of Physiology, Anatomy and Genetics, Oxford University, *England*.
2006 Instituto de Neurociencias de Alicante, Universidad Miguel Hernandez, *Spain*.
2006 Max Planck Institute for Medical Research, Dept. Cell Physiology, Heidelberg, *Germany*.
2006 Mahoney Institute of Neurological Sciences colloquium, Univ. Pennsylvania, Philadelphia, PA.
2006 Translational Neuroscience Seminar Series, Mount Sinai School of Medicine, New York, NY.
2007 Neuroscience program, University of California San Diego, San Diego, CA.
2007 Biophysics seminar series, Rockefeller University, New York, NY.
2007 Keynote speaker, Robert Wood Johnson MD/PhD program retreat, UMDNJ, Piscataway, NJ.
2007 Seminars in Neuroscience series, West Virginia University, Morgantown, WV.
2008 Janelia Farm, Howard Hughes Medical Institute, Ashburn, VA.
2008 Department of Physiology, University College, London, *England*.
2009 Origins Institute, McMaster University, Toronto, *Canada*.
2009 Neuroscience Graduate Program seminar, McMaster University, Toronto, *Canada*.
2009 SUNY Downstate Medical Center, Brookly n, NY.
2009 Dept. of Neuroscience, Johns Hopkins University School of Medicine, Baltimore, MD.
2010 Department of Neurobiology, University of Chicago, Chicago, IL.
2011 University of Paris Descartes, Paris, *France*.
2011 Department of Neurology, Univ. Texas Southwestern Medical Center, Dallas, TX.
2011 University of Southern California, Los Angeles, CA.
2012 Google Research, Mountain View, CA.
2012 Hopkins Marine Station, Stanford University, Pacific Grove, CA.
2012 Seaver Autism Research Center, Mount Sinai School of Medicine, New York, NY.
2013 Dept. Neuroscience, Robert Wood Johnson Medical School, UMDNJ, Piscataway, NJ.
2013 Physics colloquium, Rutgers University, New Brunswick, NJ.
2014 Department of Neurology, University of California Los Angeles, Los Angeles, CA.
2014 Dept. Biochemistry and Molecular Medicine, George Washington University, Washington, DC.
2014 Neuroscience seminar series, Indiana University, Bloomington, IN.
2014 Progress in Neuroscience series, Brain and Mind Research Institute, Weill Cornell Medical College, New York, NY.
2015 Neuroscience and Medicine series, Department of Neuroscience, Pasteur Institute, Paris, *France*.
2015 Department of Biology, University of South Carolina, Columbia, SC.
2015 Okinawa Institute of Science and Technology, Okinawa, *Japan*. (visit postponed)
2016 Department of Neuroscience, Thomas Jefferson University, Philadelphia, PA.
2016 Symposium on the cerebellum and autism, Sick Kids Hospital, Toronto, *Canada* (keynote).
2017 Max Planck Institute, Jupiter, FL.
2017 Center for Computational Cognitive Neuropsychiatry, Rutgers University, New Brunswick, NJ.

2017 Department of Neurobiology, Duke University, Durham, NC.
2017 Brain Talk, Roche Pharmaceutical, Basel, Switzerland.
2017 Kavli Brain Forum, Emory University, Atlanta, GA.
2017 Biophysics Colloquium, Cornell University, Ithaca, NY.
2017 Rockefeller University, New York, NY.
2018 Children's National Hospital, Washington, DC.
2019 Neurology Grand Rounds, UCLA, Los Angeles, CA.
2021 McGill University, Montreal, Canada.
2021 Gatsby Computational Neuroscience Unit, University College London, London, *UK*.
2021 University of Minnesota Political Science, Methods colloquium, Minneapolis, MN.
2021 Rutgers New Jersey Medical School, Dept. Psychiatry, New Brunswick, NJ. (remote)
2021 University of North Carolina, Chapel Hill, NC. (remote)
2022 Netherlands Institute for Neuroscience, Amsterdam, Netherlands.
2022 Erasmus Medical College, Rotterdam, Netherlands.
2022 Kavli mini-symposium on translational neuroscience, Rockefeller University, New York, NY.
2023 Neuroscience Program, Temple University, Philadelphia, PA.
2023 NeuroWire Virtual Club, www.neurowire.ca.
2023 "The cerebellum as a statistical learning machine." Shelby White and Leon Levy Center for Mind, Brain, and Behavior Neuroscience Seminar Series, Rockefeller University, New York, NY.
2023 University of Amsterdam, Amsterdam, Netherlands.
2023 "Neurobiology, statistical analysis, and democracy reform." Max Planck Institute for Neurobiology, Munich, Germany.
2023 Math and Democracy seminar, New York University, New York, NY.

Public neuroscience and election science talks

1997 National Association of Graduate-Professional Students, 12th annual meeting, New Orleans, LA.
2001 World Congress of Science Producers, Washington, DC.
2002 Policy Fellows' retreat, American Association for the Advancement of Science, Washington DC.
2002 Science on Saturdays lecture, Princeton Plasma Physics Laboratory, Princeton, NJ.
2004 Phi Beta Kappa induction dinner, Princeton University.
2005 Nassau Club, Princeton, NJ.
2005 Discussion panelist. Blurry vision: bridging the gap between science and the public. Princeton Dept. Molecular Biology and New York Academy of Sciences meeting. November 8, 2005.
2006 Princeton Alumni Council outreach trip, Seattle, WA.
2006 Princeton Tiger Talk for high school students, Princeton, NJ.
2007 Discussant, panel on career development, Society for Neuroscience, San Diego, CA.
2007 Princeton Alumni Council outreach trip, Los Angeles, CA.
2008 Smithsonian Associates, Washington, DC.
2008 Princeton Alumni Council outreach trip, Hong Kong, China.
2008 Brainwave series, discussion of creativity and the brain with Sandra Aamodt and director Julie Taymor, Rubin Museum of Art, New York, NY.
2008 authors@google, Mountain View, CA.
2008 Panel discussion on science writing: "Crystals, Quarks, Biomes and Genomes: How to Make Complex Science Compelling." Princeton University, Princeton, NJ.
2008 Conference on Learning and the Brain, MIT, Cambridge, MA.

2008 Panel discussion on the Challenges of the Brain, sponsored by *Discover* magazine/NSF/Franklin Institute. Philadelphia, PA.
2008 Renaissance Weekend, Charleston, SC.
2009 Princeton Regional Chamber of Commerce, Princeton, NJ.
2009 Brainwave series, discussion of science and Buddhism with Donald S. Lopez Jr., Rubin Museum of Art, New York, NY.
2009 Adventures of the Mind mentoring summit, Institute for Advanced Study, Princeton, NJ.
2009 TEDxSF talk, San Francisco, CA. www.tedxsf.org.
2010 Speaker, freshman address, Princeton University.
2011 Annual David Wilkinson Lecture, Harold R. Medina Seminar for State and Federal Judges, Princeton, NJ.
2011 Adventures of the Mind mentoring summit, Missoula, MT.
2012 Conference on Learning and the Brain (keynote address), Columbia University, New York, NY.
2012 Annual David Wilkinson Lecture, Harold R. Medina Seminar for State and Federal Judges, Princeton, NJ.
2012 Common Ground (local K-12 schools consortium), Princeton, NJ.
2013 Parents and Science lecture series, Rockefeller University, New York, NY.
2013 Riverside Elementary School, Princeton, NJ.
2013 Annual David Wilkinson Lecture, Harold R. Medina Seminar for State and Federal Judges, Princeton, NJ.
2013 AAAS Science and Technology Fellowship Year-End Summit, Silver Spring, MD.
2013 Conference on Active, Engaged Minds (Learning And the Brain), Boston, MA.
2014 The Science Behind The Science Behind The News, discussion of neuroscience with Joe Palca, Smithsonian Institution, Washington, DC.
2014 Understanding Autism, SciCafe, American Museum of Natural History, New York, NY.
2014 Invited panelist, Society for Neuroscience Professional Development Workshop on Teaching Neuroscience.
2016 Annual David Wilkinson Lecture, Harold R. Medina Seminar for State and Federal Judges, Princeton, NJ.
2016 Partnership for Maternal and Child Health of Northern New Jersey - annual meeting, Newark, NJ.
2017 Grand Rounds, Princeton House, Princeton, NJ.
2018 Science on Saturdays lecture, Princeton Plasma Physics Laboratory, Princeton, NJ.
2018 Paul D. Bartlett Lecture at the Linda Hall Science and Technology Library, Kansas City, MO.
2019 Old Guard of Princeton, Princeton, NJ.

TEACHING AT PRINCETON (* = NEW COURSE)

F2000-01 *MOL 508 - Neurobiology (with Berry, Tsien in different years)

F2001-06, 2008 *MOL 408 - Neurobiology (w/Berry, Gould, Eggenschwiler, Haxby in different years)

S2002 *MOL 549 - Laboratory in Neurophysiology (with Gelperin/Tank)

F2006 *MOL 90 - Advanced Seminar in Cellular and Systems Neuroscience

S2009-10 MOL 214 - Introduction to Cellular and Molecular Biology (co-instructor)

F2009-16 *NEU501 - Neuroscience Ph.D. core course (co-instructor)

S2010-14 *NEU101 - Neuroscience and Everyday Life (with Gelperin)

S2012-13, 2015 *MOL451 - Genes, Brain, and the Human Mind (with Rosenberg 2012-13)

S2017 *FRS178 - Statistics, Journalism, and the Public Interest

F2018 WWS 591b - Graduate policy workshop on election law and gerrymandering

This workshop led to the publication of A Commissioner's Guide to Redistricting in Michigan. http://gerrymander.princeton.edu/michigan

S2021 *AMS403 - Fixing A Bug in Democracy: Math and Practice of Fair Redistricting (with Grofman, Cervas)

F2021, S2024 *NEU460 - The Cerebellum in Action and Cognition

F2017, 2018, 2019, 2021, 2022
NEU501A-MOL501A – Neuroscience Ph.D. core course (course organizer)

SERVICE AT PRINCETON

Molecular Biology:

2000-2011 Department of Molecular Biology Seminar Committee
2001 Symposium planner, Dynamics in Biological Networks (with S. Tilghman and S. Tavazoie)
2008-2011 Graduate Committee, Department of Molecular Biology
2010 Departmental grant for multiphoton microscope (S10 RR026665)
Spring 2017 Oversight of Statistics and Machine Learning 201 (SML 201)

Neuroscience:

2003-present Executive Committee, Program in Neuroscience (term expires 6/2016)
2008-2012 Curriculum Committee, Neuroscience Institute
2008-2012 Graduate Admissions Committee, Neuroscience Ph.D. Program
2010-2020 C.V. Starr Fellowship Committee, Neuroscience Institute
2013-2014 Neuroscience Institute, junior faculty search committee
2013-2018 Graduate Admissions Committee, Neuroscience Ph.D. Program
2017-2018 Search committee, faculty recruitment in molecular/cellular neuroscience
2017-present Reorganization and course directorship, NEU501A (core graduate course)
2022-present Curriculum committee
2022 Animal research faculty committee
2023-present Co-director, Rutgers Medical-Princeton University M.D.-Ph.D. program

University:

2001-2002 Fellow, Rockefeller College
2003-2007 Adviser, Forbes College
2005-2008 University Committee on Committees
2006-2010 University Committee on Public Lectures, chair (two terms)
2006-2008 Curriculum Committee, Undergraduate Certificate in Neuroscience program
2007-present Fellow, Forbes College
2010 Freshman address speaker, Class of 2014
2008-2011 Institutional Animal Care and Use Committee, chair
2009-2011 Fellow, Old Dominion
2013, Fall University Committee on Committees (one term only, vacancy substitution)
2014 Animal Research Communications Working Group, Office of Dean for Research
2014, Fall University Committee on Committees (one term only, vacancy substitution)
2015-2017 University Institutional Biosafety Committee

2016-2017 University Committee on Student Life
2017-2018 Faculty Advisory Committee on Appointments and Advancements (C/3)
2019 Freshman Pre-read Assembly, Class of 2023 (with James Williams and Prof. Jennifer Rexford)
2018-2023 University Institutional Biosafety Committee
2019-2021 University Committee on Public Lectures
2019-present New Jersey Alliance for Clinical and Translational Science (NJ ACTS), Pilot Grants Program co-lead with Arnold Rabson, Rutgers and Guiling (Grace) Wang, NJIT. NIH UL1 TR003017, KL2 TR003018, TL1 TR00301.
2021 Panelist, "In the Public Eye: Communicating Outside the Academy" with Catherine Zandonella, Ben Chang, Keeanga-Yamahtta Taylor. For junior faculty.
2023 Symposium presenter, Princeton Catalysis Initiative.

STUDENTS AND POSTDOCS

Undergraduate students:
(37 students: 25 MOL, 11 NEU, 3 PHY, 3 PSY, 3 COS, 3 independent concentrators, 1 EEB, 1 CHM)

Damon Clark '01 (Physics) As his junior independent work, defined the cerebrotype as a measure of brain scaling. This work was published in *Nature*. Ph.D. Harvard Univ.; now faculty, Yale MCDB.

Jennifer Shultz '01 (Molecular Biology) Shultz's senior year work investigated axon scaling across brain evolution. Her project received a departmental best thesis award and launched a major project published in the *Journal of Neuroscience*. M.D. Univ. of Iowa, now attending dermatologist, Austin, TX.

Mark Burish '02 (Molecular Biology) Burish's senior thesis on bird brain evolution was published in *Brain, Behavior and Evolution*. M.D./Ph.D. Vanderbilt Univ.; now faculty, University of Texas Houston.

Hao Yuan Kueh '02 (Physics) Kueh and Burish collaborated on the bird project. Ph.D. Harvard Univ.; now faculty, University of Washington.

Matthew Wagers '03 (Molecular Biology) Wagers contributed to the axon scaling project. Ph.D. Univ. of Maryland; now faculty, UC Santa Cruz.

Samuel Hall '03 (Molecular Biology) Hall's senior thesis on neural prosthetics received a departmental best thesis award and was published in *Slate*. Wall Street; Ph.D. U. Cambridge.

Lily Johnston '05 (Psychology) Johnston worked on scaling of cerebellar neurons. M.D. UCSD.

Varun Phadke '05 (Molecular Biology) Worked on scaling of bird brains and cerebellar neurons. Phadke was the Class of 2005 valedictorian. M.D. Harvard Medical School (M.D.) Now faculty, Emory University.

David Matthews '05 (Molecular Biology) Worked on cerebellar synaptic learning rules. Ph.D. UCSD.

Chelsea Meskunas '06 (Molecular Biology) Reviewed overuse of headache medication. Senior thesis was published in *Headache*. M.D. Mount Sinai, now faculty, UCLA.

Natalia Balko '07 (Molecular Biology) M.B.A. Stanford, now VP, IQVIA.

Jonathan Charlesworth '07 (Molecular Biology) Worked on in vivo cerebellar imaging. Ph.D. UCSF, now VP, Clinical Research, Noctrix Health.

Justin Huynh '07 (Molecular Biology) Worked on cerebellar synaptic learning rules. Now director at Liquidware.

Hyunyoung Megan Lee ’08 (Independent Concentration, Computational Biology) Developed clustering algorithms for analyzing in vivo imaging. M.D. University of Maryland.

Andrew Bluher ’09 (Molecular Biology) Worked on canine brain scaling. M.D. University of Maryland. Now faculty, Washington University in St. Louis.

Shihab Ali ’11 (Molecular Biology) Worked on canine brain scaling. M.D. Brown University.

Charlotte Arlt ’11 (University of Cologne) Developed in vivo imaging methods. Ph.D. University College London, now editor at *Nature Communications*.

David Tsao ’11 (Physics) Developed in vivo imaging methods. CTO, BillionToOne.

Diya Das ’12 (Molecular Biology) Worked on canine brain scaling. Das’s senior thesis received a Neuroscience Institute best thesis award. Ph.D. UC Berkeley. Genentech.

Daniel Chang ’13 (Molecular Biology) Worked on calcium sensor design. Post-baccalaureate.

Sara Connolly ’13 (Ecology & Evolutionary Biology) Eyeblink conditioning in autism model mice. Ph.D. study at Stanford University.

Tierney Kuhn ’13 (Computer Science) Developed methods for genomic and phenotypic analysis of intellectual interests. IdeaFlow.

Diana Shi ’13 (Psychology) Developed a new caged GABA compound for emulating inhibition in intact brain tissue. Shi received a best thesis award and published her work in *Journal of the American Chemical Society*. M.D. Harvard, now in fellowship.

Richard D. Jones ’13 (Psychology) Discovered backward blocking, a form of Bayesian learning, in cerebellar learning. Post-baccalaureate.

Amy Li ’14 (Molecular Biology) Investigated eyeblink conditioning in autism model mice. M.D. Stanford, now resident at Georgetown.

Adriana Cherskov ’14 (Molecular Biology) Investigated eyeblink conditioning in autism model mice. Gates Scholar at Cambridge University. M.D./Ph.D. study at Yale University.

Yekaterina Shulgina ’15 (Molecular Biology) Genomic analysis of normal-range traits in relatives of persons with autism. Shulgina received the John Brinster '43 prize for best neuroscience thesis, and the Sigma Xi book prize for best molecular biology thesis. Ph.D. Harvard University.

Thaddeus Weigel ’15 (Molecular Biology) Tracing of synaptic pathways from cerebellum to forebrain. NIH, Ph.D. study at University of Virginia.

Kiran Vodrahalli ’16 (Computer Science) Clustering analysis of intellectual phenotypes.

Julia Metzger ’16 (Molecular Biology) Cerebellar roles in development of nonmotor functions. Metzger received the best thesis award in Quantitative and Computational Biology and an outstanding thesis award in Molecular Biology.

Shruthi Deivasigamani '16 (Molecular Biology) Tracing of synaptic pathways from cerebellum to forebrain.

Christine Hildreth '16 (Independent Concentration, Neuroscience) Cerebellar roles in development of nonmotor functions.

Marissa Applegate '16 (Chemistry) Acceleration of Fast-GCaMP responses for tracking neuronal activity. Ph.D., Columbia University, completed 2023.

Alice J. Tao '17 (Neuroscience) Contributions of cerebellar activity to cognitive and social behavior in mice. Tao received the John Brinster '43 Senior Thesis Prize in Neuroscience.

Joyce C. Lee '17 (Neuroscience). Going to Boston University School of Medicine.

Rob Aguilar '17 (Computer Science). Convolutional neural networks for recognizing neurons in fluorescence images.

Alicia Lai '18 (Neuroscience) University of Pennsylvania Law School / Stanford Law School.

B.C. Cho '18 (Electrical Engineering)

Patricia Aguiar '19 (Neuroscience)

Christina Matl '19 (Molecular Biology)

Tiffany Chen '20 (Molecular Biology)

Tiffany Pham '20 (Molecular Biology)

Xiaoting Sun '20 (Neuroscience)

Ali Munson '21 (Neuroscience)

Angela Li '21 (Neuroscience)

Kara Steele '21 (Neuroscience)

Katherine Kaplan '22 (Neuroscience)

Mina Musthafa '22 (Neuroscience)

Samuel Frank '22 (Molecular Biology)

Eliyana Abraham '23 (Neuroscience) - smartphone-based neurometric testing for ADHD.

Dafna Yavetz '23 (Molecular Biology) - critical periods for the development of flexible behavior.

Rachel Tam '24 (Neuroscience) - machine vision for analysis of mouse social interactions.

Katelyn Ryu '24 (Neuroscience) -

Anurag Pratap '24 (Neuroscience) - two-photon spine imaging in vivo.

Thussenthan Walter-Angelo '24 (Molecular Biology) - Aldoc-specific manipulation and imaging of PCs.

Veronica Zhang '25 - functional organization of cerebellar activity in human development and autism

Graduate students (fellowships underlined):

Dmitry Sarkisov (2000-2007, Ph.D. Physics) Sarkisov studied coincidence detection by IP_3 single dendritic spines of cerebellar Purkinkje neurons. Now in financial industry.

Gayle Wittenberg (2001-2003, Ph.D. Molecular Biology, 2003-2006 Council on Science and Technology teaching fellow) Wittenberg studied spike timing dependent plasticity in hippocampus. Now a group leader at Janssen Research.

Kim Hatch Harrison (2002-Spring 2003; M.A. in Molecular Biology) Harrison studied evolutionary scaling principles of axons.

Daniel O'Connor (2002-2006; M.A. Psychology, Ph.D. Molecular Biology) O'Connor held a National Science Foundation Graduate Fellowship. He studied learning rules at single hippocampal synapses, and developed patterned uncaging methods. Now an associate professor at Johns Hopkins University.

Megan Sullivan (2002-2006; Ph.D. Molecular Biology) Sullivan held a National Alliance for Autism Research graduate fellowship. Sullivan pioneered in vivo imaging of cerebellar circuitry.

Eve Schneider (2007-2012; Ph.D. Psychology) Schneider discovered dendritic excitability in the deep cerebellar nuclei. Now an assistant professor at University of Kentucky Lexington. Alfred P. Sloan Fellow.

Xiaonan Richard Sun (2007-2012; Ph.D. Molecular Biology, M.D. at UMDNJ) Sun developed Fast-GCaMP sensors for rapid sensing of neuronal calcium. Now in neurosurgery fellowship at North Shore Long Island Jewish Hospital.

Alexander Kloth (2009-2014; Ph.D. Molecular Biology and Neuroscience) Kloth discovered cerebellar circuit defects in a wide variety of autism models. He received an F31 NRSA predoctoral fellowship and is now an assistant professor at Augustana University.

Matthew J. Howard (2012-2014; M.A. Molecular Biology) Howard investigated synaptic pathways between cerebellum and nonmotor regions of forebrain. Now in financial services.

Benjamin Campbell (2011-2014; Rockefeller University) Campbell formulated theories of nonmotor function for cerebellum. Now working in Silicon Valley.

Thomas J. Pisano (2014-2019; M.D.-Ph.D. program, Rutgers/Princeton) Pisano traced long-distance pathways linking the cerebellum with cognitive- and reward-related centers in the forebrain and basal ganglia. Funded by an F30 NRSA M.D.-Ph.D. fellowship award. Going to neurology residency at the University of Pennsylvania.

Ben Deverett (2014-2019; M.D.-Ph.D. program, Rutgers/Princeton) Deverett developed head-fixed approaches to a working memory task in collaboration with the Tank laboratory. The preparation was used to probe cerebellar contributions to working memory and sensory evidence accumulation. Funded by an F31 NRSA M.D.-Ph.D. fellowship award. Going to anesthesiology residency at Stanford University.

Yuhang Chen (2020-2022; M.A., Quantitative and Computational Biology).

Fred Uquillas (2020; Ph.D. program in Neuroscience). Co-advised by Prof. Jesse Gomez. Recipient of NSF Graduate Fellowship.

Postdoctoral research associates (fellowships underlined):

Shy Shoham (2001-2005) Dr. Shoham arrived at Princeton as a Lewis Thomas Fellow. He designed and constructed a system for uncaging neurotransmitters to activate brain tissue in defined patterns. Professor at NYU.

Bernd Kuhn (2004-2010) Dr. Kuhn developed methods for cell-type-specific expression of calcium indicator proteins, and imaging them in vivo. Group Leader at Okinawa Institute of Science and Technology.

Ilker Ozden (2004-2010) Dr. Ozden pioneered the use of calcium-sensitive indicator proteins for imaging cerebellar circuitry. He was an Autism Speaks postdoctoral fellow, and is now on the faculty at University of Missouri Columbia.

Tycho Hoogland (2005-2009) Dr. Hoogland discovered waves of activity encompassing hundreds of glial cells in cerebellum. He is now a group leader at the Netherlands Institute for Neuroscience.

Eugene Civillico (2006-2009) Dr. Civillico was a Patterson Trust postdoctoral fellow. He used patterned uncaging methods to discover rules for local signal summation in cerebellar Purkinje cell dendrites. Now a research program official at the US Food and Drug Administration.

Stephen Lin (2010-2011) Dr. Lin is a former research group leader from Wyeth Labs. At Princeton he investigated signaling properties of calcium signaling proteins. Retired.

P. Alexander Argüello (2010-2012) Dr. Argüello traced synaptic pathways between frontal cortex and cerebellum. He is now a program officer at NIMH.

Andrea Giovannucci (2010-2017) Dr. Giovannucci discovered how the cerebellum encodes learned stimuli during eyeblink conditioning, a form of cerebellar learning. He was a New Jersey Commission on Brain Injury Research postdoctoral scholar. Now faculty at University of North Carolina.

Aleksandra Badura (2012-2018) Dr. Badura tested the hypothesis that the cerebellum acts during developing as a teacher of higher cognitive processes. She also helped develop and test fast-responding fluorescent calcium sensor proteins. She recently received a Veni career development fellowship from the Netherlands Organization for Scientific Research (NWO).

Jessica Verpeut (2015-2020) Dr. Verpeut is testing the hypothesis that the cerebellum acts during developing as a teacher of higher cognitive processes. She was awarded a New Jersey Commission on Brain Injury Research postdoctoral scholarship.

Mikhail Kislin (August 2015-present) Dr. Kislin is using the monitoring of freely-moving mice to test the hypothesis that the cerebellum carries information specific to the performance of cognitive tasks.

Kelly Seagraves (2016-2020) Dr. Seagraves was a C.V. Starr Fellow hosted by the Wang laboratory. She is interested in neural mechanisms of social learning in freely behaving rodents, and in whole-brain mapping of neural activity at cellular scale. She was awarded a 2020-2021 Executive Branch AAAS Fellowship to work on cyberintrusions for the U.S. State Department.

Will Adler (2018-2019) worked on the Princeton Gerrymandering Project developing quantitative approaches to analytics and communication. His Ph.D. was in computational neuroscience. He has a 2019-2020 Congressional AAAS Fellowship to work on oversight for Senator Elizabeth Warren.

Marlies Oostland (2018-2021). Dr. Oostland was a Marie Curie Fellow and is now an assistant professor at the University of Amsterdam.

Henk-Jan Boele (August 2018-present). Dr. Boele was awarded a postdoctoral grant from the New Jersey Commission on Medical Treatment and Research on Autism. Now an assistant professor at Erasmus Medical College with additional appointment at Princeton University..

Sara Guariglia (2021-2023). Dr. Guariglia worked on neocortical dendritic spine regulation. Now an independent staff scientist at New York State Institute for Basic Research.

Junuk Lee (September 2017-July 2023). Dr. Lee worked on the role of norepinephrine in cerebellar learning. Van Andel Institute, Grand Rapids, Michigan.

G. Joseph Broussard (September 2018-present). F32 BRAIN Initiative postdoctoral fellowship to investigate parallel fiber population coding using fast-GCaMP sensors during learning.

Jesse T. Clark (2021-2022). Dr. Clark performed research on election systems.

Esra Sefik (2022-present). C.V. Starr Fellow hosted by the Wang laboratory to work on the postnatal trajectory of neocortical dendritic spine maturation and its regulation by cerebellar activity.

External teaching activities

Mar.-Apr. 2008 *Workshop co-organizer, Kavli Institute for Theoretical Physics.* Program on Anatomy, Development, and Evolution of the Brain.

Summer 2012-13 *Invited lecturer,* summer course, Biophysics and Computation in Neurons and Networks. Organized by Alan Gelperin, David Tank, and Michael Berry.

Summer 2015-17 *Invited lecturer,* summer course, Neurotechnologies for Analysis of Network Dynamics (NAND). Organized by Gelperin, Tank, and Berry.

Summer 2018-19 *Invited lecturer,* summer course, Cellular, Cognitive, and Computational Neuroscience (C3N). Organized by Gelperin, Tank, and Berry.
Summer 2023 *Invited lecturer,* undergraduate biophysics summer school, Center for the Physics of Biological Function. Organized by Joshua Shaevitz, William Bialek, and William Jacobs.
Summer 2023 *Workshop organizer*, Electoral Innovation Lab.